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***Uso de tela de malha larga impregnada com lambda-cyhalotrina como método de controle vetorial***

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### Abstract

An alternative vector control method, using lambda-cyhalothrin impregnated wide-mesh gauze covering openings in the walls of the houses was developed in an area in the Eastern part of the interior of Suriname. Experimental hut observations showed that *Anopheles darlingi* greatly reduced their biting activity (99-100%) during the first 5 months after impregnation. A model assay showed high mortality both of mosquitoes repelled by the gauze as well as of those that succeeded in getting through it. A field application test in 270 huts showed good acceptance by the population and good durability of the applied gauze. After introducing the method in the entire working area, replacing DDT residual housespraying, the malaria prevalence, of 25-37% before application dropped and stabilized at between 5 and 10% within one year. The operational costs were less than those of the previously used DDT housespraying program, due to a 50% reduction in the cost of materials used. The method using wide-mesh gauze impregnated with lambda-cyhalothrin strongly affects the behavior of *An. darlingi*. It is important to examine the effect of the method on malaria transmission further, since data indirectly obtained suggest substantial positive results.

**Mosquito control, methods. Malaria, prevention and control. Insecticides.**

### Resumo

Foi desenvolvido, na parte oriental do interior do Suriname um método alternativo de controle antivetorial, usando uma tela de malha larga impregnada com lambda-cyhalotrina, cobrindo as aberturas das paredes das casas. Observações com casas experimentais mostraram uma redução de picadas muita alta (99%) de *Anopheles darlingi* durante os primeiros 5 meses após a impregnação. Um ensaio mostrou alta mortalidade dos mosquitos, repelidos ao tentar passar pelo tule, além daqueles que conseguiram passar. A aplicação no campo revelou resultados promissores deste método de controle antivetorial, boa aprovação da população e baixos custos operacionais em relação à borrifação residual com DDT.

**Controle de mosquitos, métodos. Malária, prevenção & controle. Inseticidas.**

## INTRODUCTION

During the past four decades residual house spraying has been used as a vector control method in Suriname. Dieldrin, malathion and DDT have all been used as insecticides, the last more extensively. This method has undergone no significant change throughout this period, although provoking many questions about its effectiveness against malaria transmission. The problems faced in carrying out the spraying programs are well described by Barnes & Jenkins<sup>1</sup>, showing a low level of acceptance on the part of the population. Basic research into the effectiveness of the spraying method against the malaria vector *Anopheles darlingi* Root, 1926 was not undertaken until 1985. In the following, an experimental hut study demonstrated that residual house spraying in Bush Negro houses with DDT 2 g A.I./m<sup>2</sup> caused high mortality among *An. darlingi*<sup>4</sup>. However, residual house spraying has not been widely effective as a vector control method, limiting factors other than the technical aspects of the method have become evident.

A study on the effectiveness of permethrin impregnated mosquito nets<sup>3</sup> showed that despite the effectiveness of the nets against *An. darlingi*, it was impractical to introduce the method in the area due to extensive washing habits.

The present study examines the use of wide-mesh gauze impregnated with lambda-cyhalothrin covering the main openings of the Bush Negro houses as a control method against *Anopheles* species. Since earlier vector control methods were poorly adapted to local customs, this method was designed for optimum acceptance.

## METHODS

### Study area

The study area, Eastern Suriname along the Marowijne, Lawa and Tapanahony rivers (for specific information on the area see Rozendaal et al.<sup>3</sup>), was separated from the rest of the country since 1986 because of administrative problems. As a result, the health services were taken over by a humanitarian aid organization, operating separately from the Surinamese government. The development of this control method was part of the malaria control program set up by this organization.

Malaria in the study area showed high, year round transmission of *Plasmodium falciparum* and *P. malariae*. Because of the Negroid character of the human population, *P. vivax* is absent<sup>5</sup>. Entomological studies were conducted at the beginning of 1989 at the experimental station Abetredjoeka, on the Upper Marowijne.

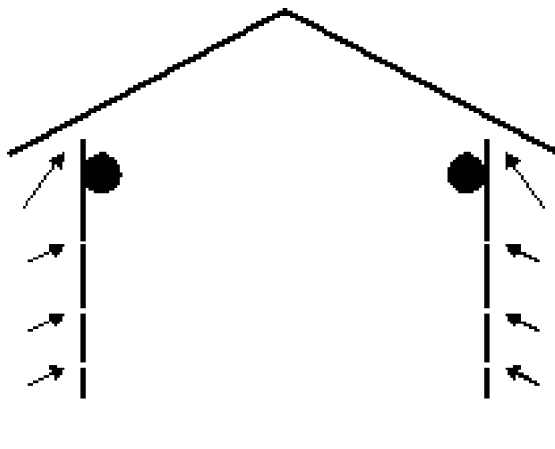


Figure 1 - Cross-sectional view of a typical Bush Negro house, showing the slits in the walls (smaller arrows) and the eave openings (larger arrows).

### Houses

A cross-section of a typical Bush Negro hut is shown in Figure 1. The main openings in the walls (made of wooden planks) are where the roof (thatched or zink plates) and the walls meet (eave-opening). Slits of various sizes between the boards of the walls are found. When the openings and slits between the boards are covered with impregnated gauze with a mesh-size big enough for a mosquito to crawl through, but too small for it to fly through, the mosquitos entering will come into contact with insecticide. Some mosquitos enter unhampered since it is not possible to cover all the bigger slits. As *An. darlingi* is an exophilic mosquito, it will leave within a few hours after its blood meal<sup>5</sup>, usually well before the inhabitants open their doors in the morning. The method was developed in such a way as to be well adapted to the customs of the house owners.

### Gauze Impregnation

The gauze used was a black 100 % nylon netting with 6 mm trapezoidal shaped holes. The netting was impregnated with synthetic pyrethroid lambda-cyhalothrin (Karate, Icon) by soaking it in a solution for 30 min. For the impregnation process plastic bags were used, such as could enable a quantity of 100 x 0.20 meters of the gauze to be impregnated at a time. The gauze was dried by hanging it over raised ropes in shadowed areas. The dried gauze was stored for a maximum period of 3 weeks in plastic bags inside metal trunks for transportation. All initial impregnations were confirmed by gas chromatography. Reimpregnation of gauze already in use in the huts was done by brushing a lambda-cyhalothrin solution onto it. The dosage for the standardized reimpregnation technique was calculated from test-chamber experiments with pieces of gauze which had had several insecticide concentrations, using dose-response comparisons between known concentrations and gauze samples treated with several brush-on techniques.

## Test-Chamber

The first tests were made using a specially developed test-chamber, consisting of two chambers of 15 x 15 x 15 cm each, separated by a piece of gauze. In the front chamber freshly caught *An. darlingi* females were released, while the end of the hind chamber was pressed against the observer's abdomen. A piece of fine-mesh netting was positioned between the bait and the mosquitos, enabling them to make contact with the bait. The tops of the chambers were made of Plexiglas, so that the mosquitos inside the test-chamber could be observed. From zero-time (mosquito release; maximum of 10 mosquitos at a time) the number of mosquitos that passed the netting was counted every minute, and the condition of all mosquitos was noted. Gauze pieces impregnated with lambda-cyhalothrin in concentrations from 4 to 27 mg/m<sup>2</sup> were tested. As a control a piece of untreated gauze was used.

## Experimental Huts

The experimental hut study was carried out by using two similar huts, resembling local huts, as described in Rozendaal et al<sup>4</sup>. One of the huts was provided with gauze impregnated with lambda-cyhalothrin (11 mg/m<sup>2</sup>) covering all openings (eave-openings and slits along the main walls, close to the floor). The other hut was used as a control, using untreated gauze to cover the openings. During a period of two months observers sat daily in each hut recording the total number of biting *An. darlingi* from 2100 h until 0200 h, leaving the lower part of their legs exposed. After this two month period the observations were continued during selected months until a decline in insecticidal activity was indicated. Mosquitos collected from the exit traps (approximately 50% of the total recorded bites) were identified, and the number of *An. darlingi* recorded. After each observation night the floors of the huts (covered with light-colored plastic) were searched for dead mosquitos for 15 min. each using a flashlight.

## Field Application

The first area in which the gauze was applied in August-September 1989 contained 270 houses along a 30 km stretch of river. After the initial application of the method the area was kept under observation for 6-month period.

Since the author always slept on the camp-sites where he worked, extensive communication with the people was possible before and after treating their houses. During this

test-phase information was collected on the quantities of materials used, duration of application and reactions of the population towards the method. Also, the local people from the test application area were followed-up intensively as to their behaviour as regards visiting the dispensaries and whether they acquired malaria infections, using passive case detection data.

After the test phase the method was introduced into the entire eastern part of the Surinamese interior, replacing DDT residual house spraying. During this phase information was collected on operational costs, malaria prevalence in the working area using passive case detection data and acceptability of the method.

## RESULTS

### Test-Chamber

Table 1 shows the observations made of the mosquitos in the test-chamber experiment. In tests with untreated gauze 88% of *An. darlingi* passed the netting. This proportion was drastically reduced with all tested concentrations. A high proportion of the mosquitos that did not pass the netting died within 15 min with all concentrations. All mosquitos that passed the impregnated netting died shortly afterwards, whereas the control gauze did not cause mortality.

### Experimental Huts

The results from the experimental hut studies are shown in Table 2. In a pre-impregnation test both huts yielded the same number of biting *An. darlingi*. During the first 5 months after impregnation an almost complete biting reduction was observed in the treated hut. During months 6 and 8 the biting increased to 33% and 76% of the control respectively. In month 11 no significant insecticidal activity was observed. After re-impregnation the expected biting reduction of 100% was established again. No dead mosquitos were found on the floors of the experimental huts.

### Field Application

The observations during the test field application revealed that on average it took 20 minutes and 1.0 m<sup>2</sup> of gauze for a trained worker to treat one hut. The

Table 1 - Results from the test-chamber observations, showing the number of *An. darlingi* that stayed in the front chamber, passed the gauze into the back-chamber, and their respective mortalities.

Observation	Lambda-cyhalothrin concentration on gauze (mg/m <sup>2</sup> )			
	Control (0)	11	18	27
% that passed the netting	88	35	31	11
% that stayed in front chamber	12	65	69	89
% mortality of mosquitos that passed the netting	0	100	100	100
% mortality of mosquitos that stayed in front chamber	0	87	94	92
n mosquitos tested	26	46	77	27

Table 2 - Total number of observed biting *An. darlingi* from experimental hut observations with impregnated wide-mesh gauze.

Impregnation	Bite count in Control Hut	Bite count in Treated Hut	N° of Observation nights	% biting reduction
Pre-impregnation				
month 0	23	23	3	-
Post impregnation				
month 1	166	2	15	99
month 5	102	0	5	100
month 6	133	44	6	67
month 8	59	45	5	24
month 11	70	63	6	10
Re-impregnation				
month 1 (= 12)	25	0	5	100

reactions of the inhabitants were very positive. Although there were no refusals for gauze application, the people were curious. With explanation the house owners understood and supported the control method. Since the applied gauze was relatively inconspicuous it did not interfere with local cultural customs. Hut occupants reported that they were annoyed less by mosquitos at night. These positive reactions continued throughout the 6 month evaluation period.

Five months post treatment, 210 of the 270 treated huts were revisited to assess the condition of the gauze. Selective discussions with the hut occupants indicated that they remained supportive and remarked on the gauze's beneficial side effects, such as killing cockroaches and wolf spiders. The check also revealed that, although the small black pieces of gauze do not bother them, the people do not neglect them. Boat paddles and wooden chairs were no longer stocked in the eave-openings, which used to be customary. Only some minor re-fastening work was necessary in 20% of the revisited huts. In one hut the gauze had been removed completely because the owner had replaced his thatched roof during this period.

Unfortunately, it proved impossible to conduct an intervention trial to produce direct evidence of the method's effect on malaria transmission. The figures on dispensary-visitation and malaria incidence in the test-area showed that, initially, the area was one of the focal areas, with proportionally more cases of malaria than others. After application of the netting, the number of *Plasmodium falciparum* and *P. malariae* infections found among the inhabitants of the test area dropped significantly in comparison to those in other areas, and continued to do so. Similar comparisons between other untreated areas revealed no such trends.

After the positive results of the entomological and application studies the entire working area was treated with the wide-mesh gauze. Only about 5% of the houses were not suitable for this method, and still received DDT spraying.

Before the start of the application of the gauze method, the malaria prevalence in the entire population of the working area was of from 25 to 37%. After the beginning of the control program the prevalence dropped, stabilizing all between 5 and 10% within a year.

## DISCUSSION

The test-chamber observations gave a good insight into the insecticidal impact of the impregnated gauze on mosquito behavior and mortality.

The smaller slits, up to a width of approximately 6 mm, are of no important as possible entrance-openings for mosquitos, because spiders cover them with their webs.

Normally, human activity outside the houses ceases around 21:30. Before this hour, less than 10% of all foraging *An. darlingi*(s) are active (Figure 2). With so little overlap of mosquito biting and human outdoor activity a vector control method acting when the people are inside their houses could be effective, when fully accepted by the population.

Majori et al.<sup>3</sup> studied impregnated eave-curtains using 1.0 g/m<sup>2</sup> permethrin as an impregnant. They found an almost complete prevention of indoor-resting mosquitos, as well as an increased exit and mortality rate, which agrees with the results of these experiments. From the present study it is not known whether the biting reduction was caused by mosquitos repelled from entering the hut or mosquitos dying while trying to enter the huts. The test-chamber experiments demonstrated high mortality among *An.*

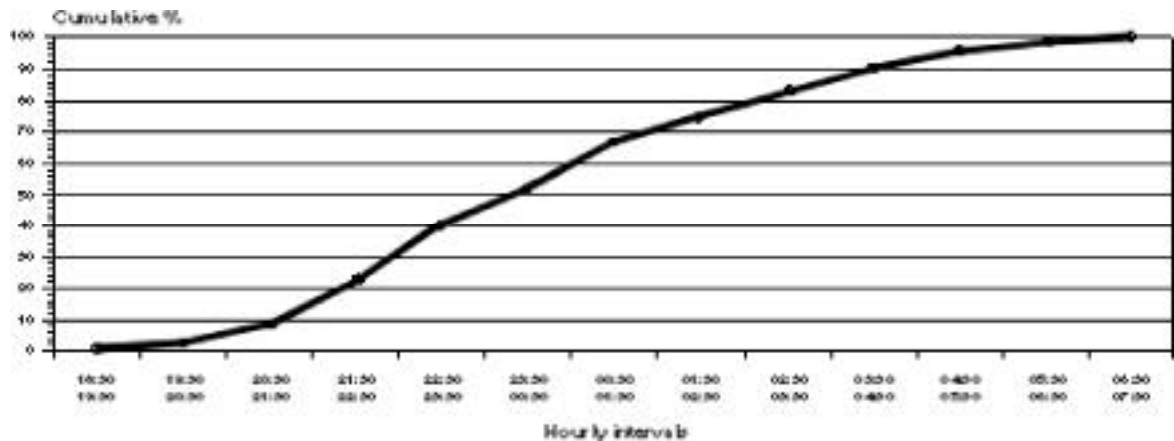


Figure 2 - Cumulative biting activity of *An. darlingi* in the study area, n=981, 35 nights.

*darlingi* white passing or attempting to pass the gauze barrier, suggesting that the mosquitos died while trying to enter rather than avoiding lethal contact.

### Field Application

The impregnated gauze method can be applied and maintained with the same number of personnel as the previous DDT house spraying. The costs of materials (gauze, insecticide, staples) was approximately 50% of the material costs of the residual house spraying program. It may be possible to use a cheaper type of gauze, reducing costs even further. Applied selectively in time the same 6-months treatment cycle as used in DDT house spraying programs can be used. Besides this, an attempt could be made to stimulate community participation in the re-impregnation activity, making only maintenance-visits necessary. Trying to convince the inhabitants to purchase the materials themselves to protect their huts would probably have very poor results due to the continuously paternalistic attitude of the governmental and non-governmental organizations that have been active in the region for many decades. Experiences within our organization with education-related purchases showed negative responses as well. As already indicated, when materials are provided participation of the inhabitants could be stimulated, because of the simple techniques and the small effort needed to apply the method and sustain it.

Besides the financial advantages, the impregnated gauze method is much safer to apply than the spraying with insecticides.

Two years after the introduction of this method throughout the area some problems arose regarding its acceptance. In certain parts of the area the people started rejecting impregnation, in the hope of having

their houses sprayed again. The request for the spraying was not because the people disapproved of the gauze method. They wanted rather, to continue to benefit from one of the side effects of the residual insecticide on their walls, that is the killing of the termites that were infesting their houses. When the malaria prevalence was as high as 34%, at the beginning of the application of the gauze method, no complaints were heard about termites. The reduction of the malaria problem showed that priorities had changed. Besides that, the side effect of killing termites had previously been used to persuade people to have their houses sprayed. This shows that one must be very careful as to how a method's side effects are used for promotion.

Unfortunately a longer follow-up of the method's field application was not possible. After the political problems in the area ended in 1992, the Surinamese government took over the responsibilities for health-care in the area again, and the method was not continued in spite of the promising results.

The method using wide-mesh gauze impregnated with lambda-cyhalothrin strongly affects the behavior of *An. darlingi*. It is important to further examine the effect of the method on malaria transmission, since data indirectly obtained suggest substantial positive results.

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